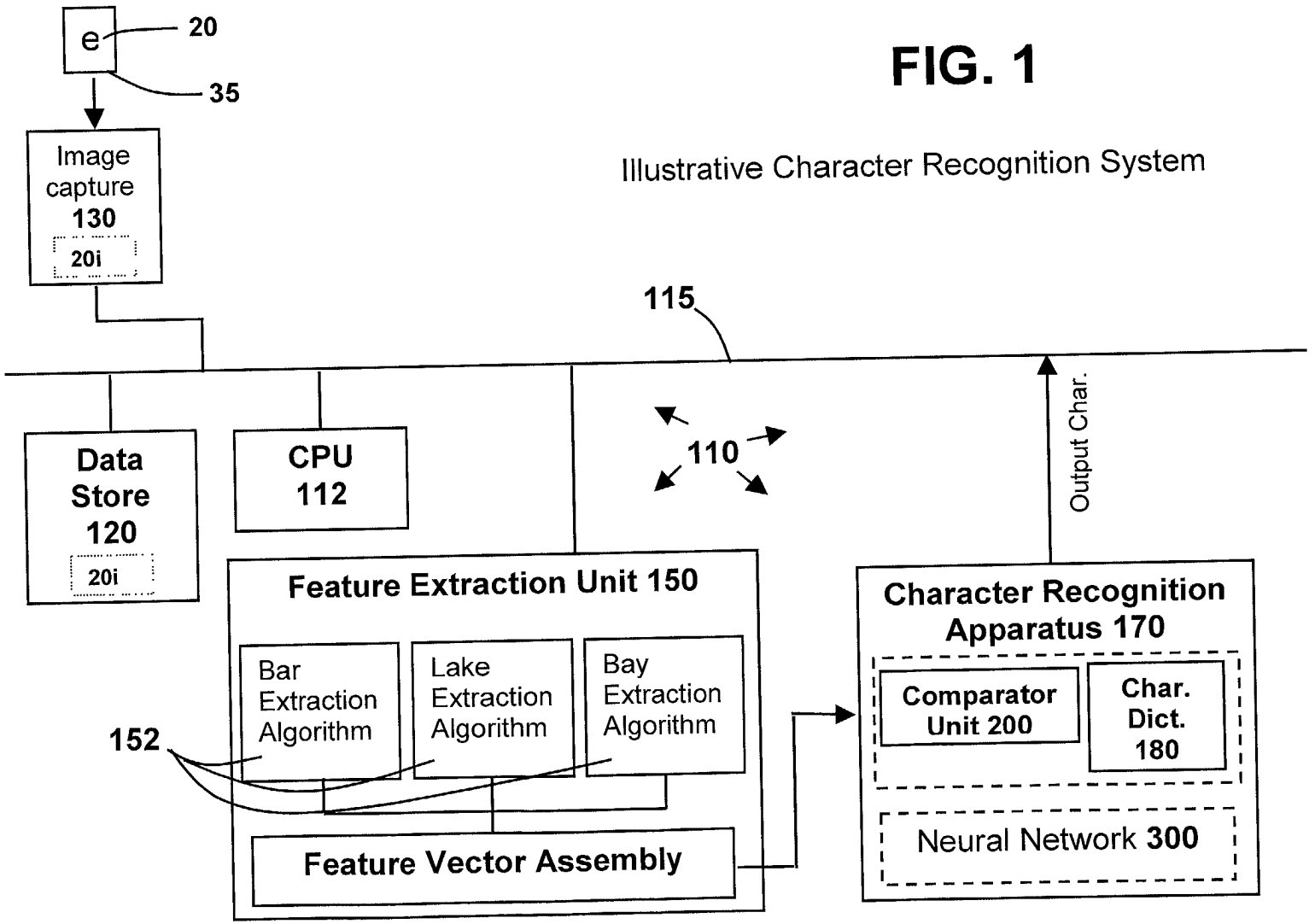
# FIG. 1

Illustrative Character Recognition System



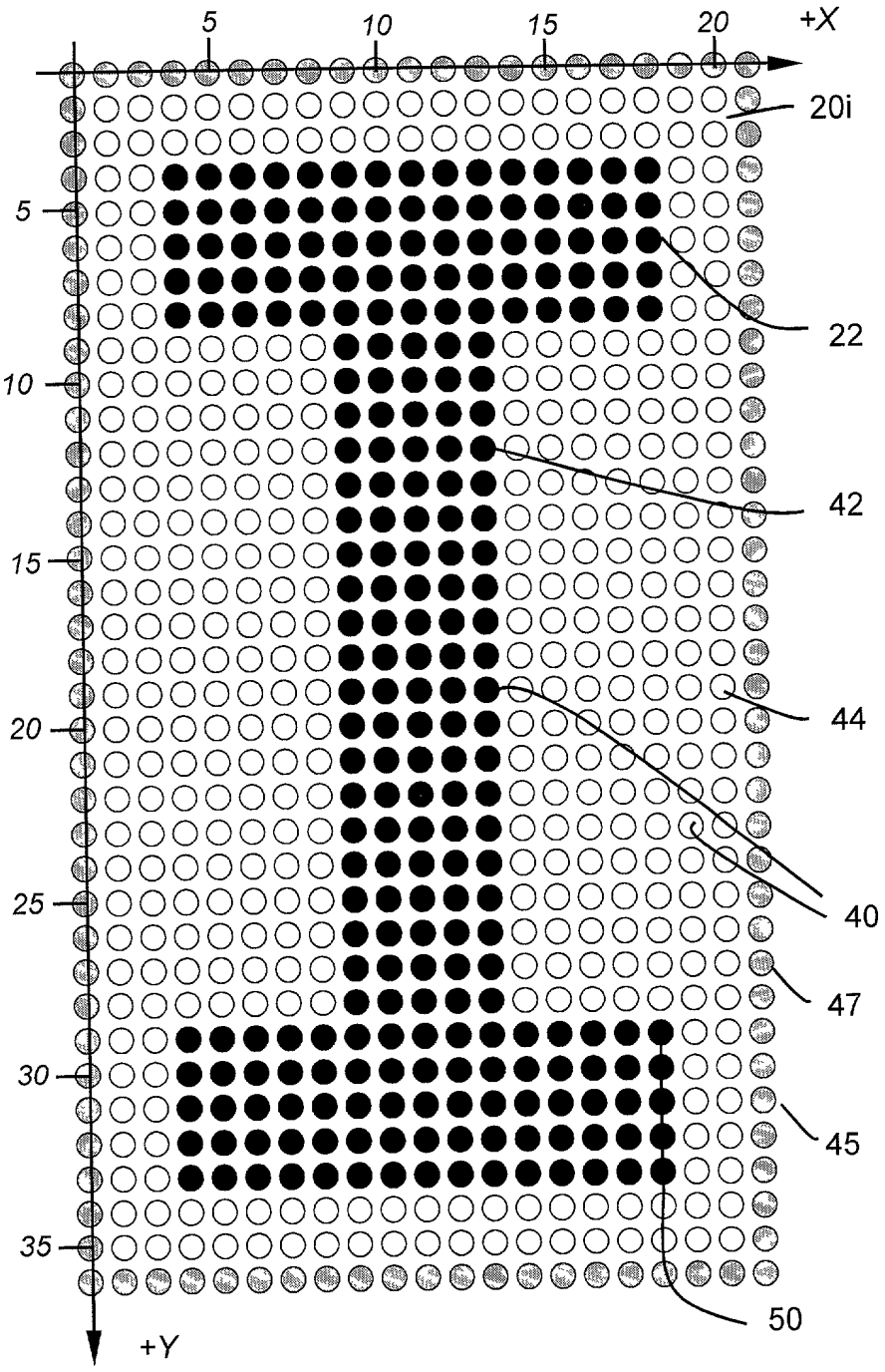



FIG. 2

Magnified character "I" revealing constituent pixels

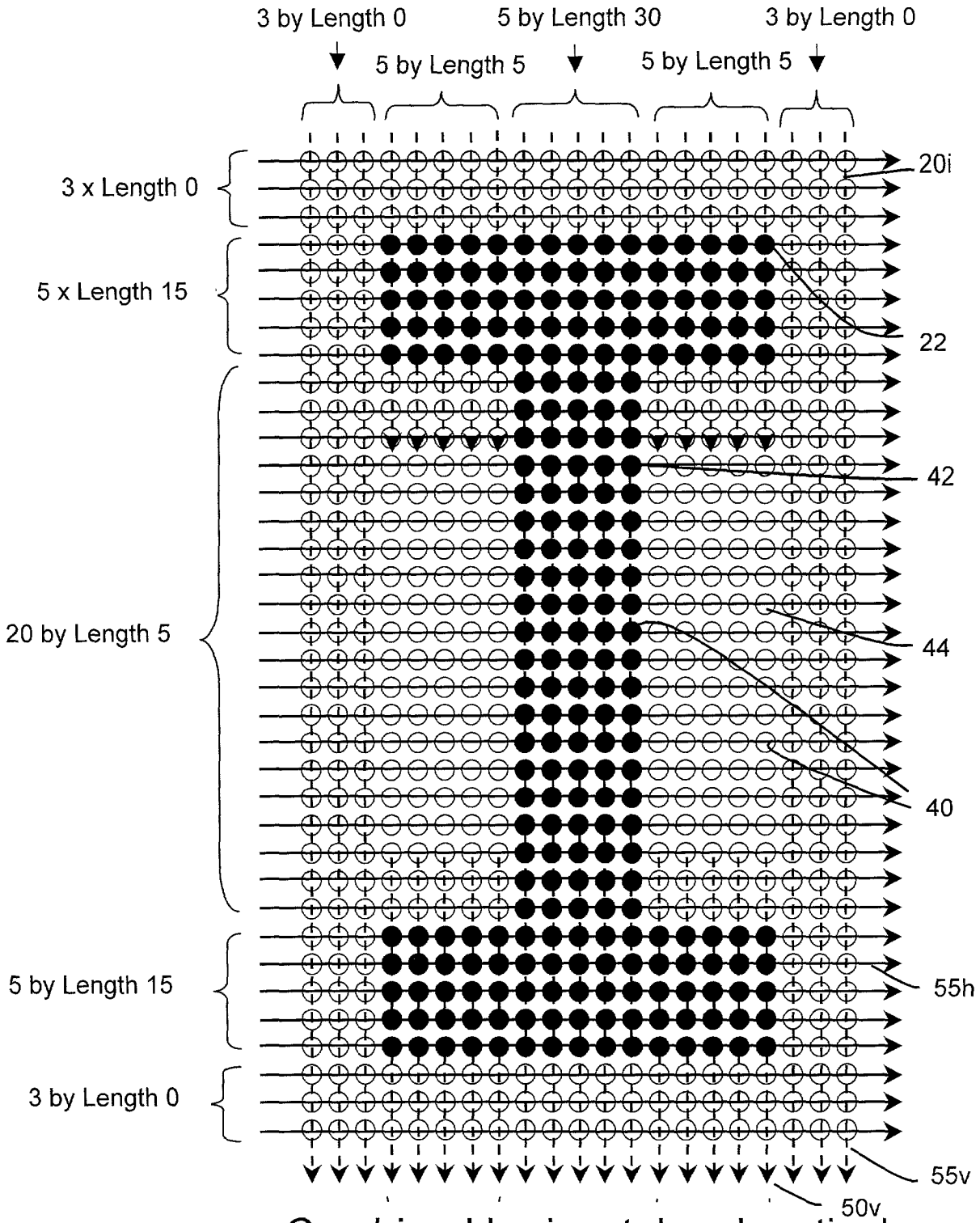



FIG. 2a

Combined horizontal and vertical algorithmic pixel-counting scan for average run-length determination

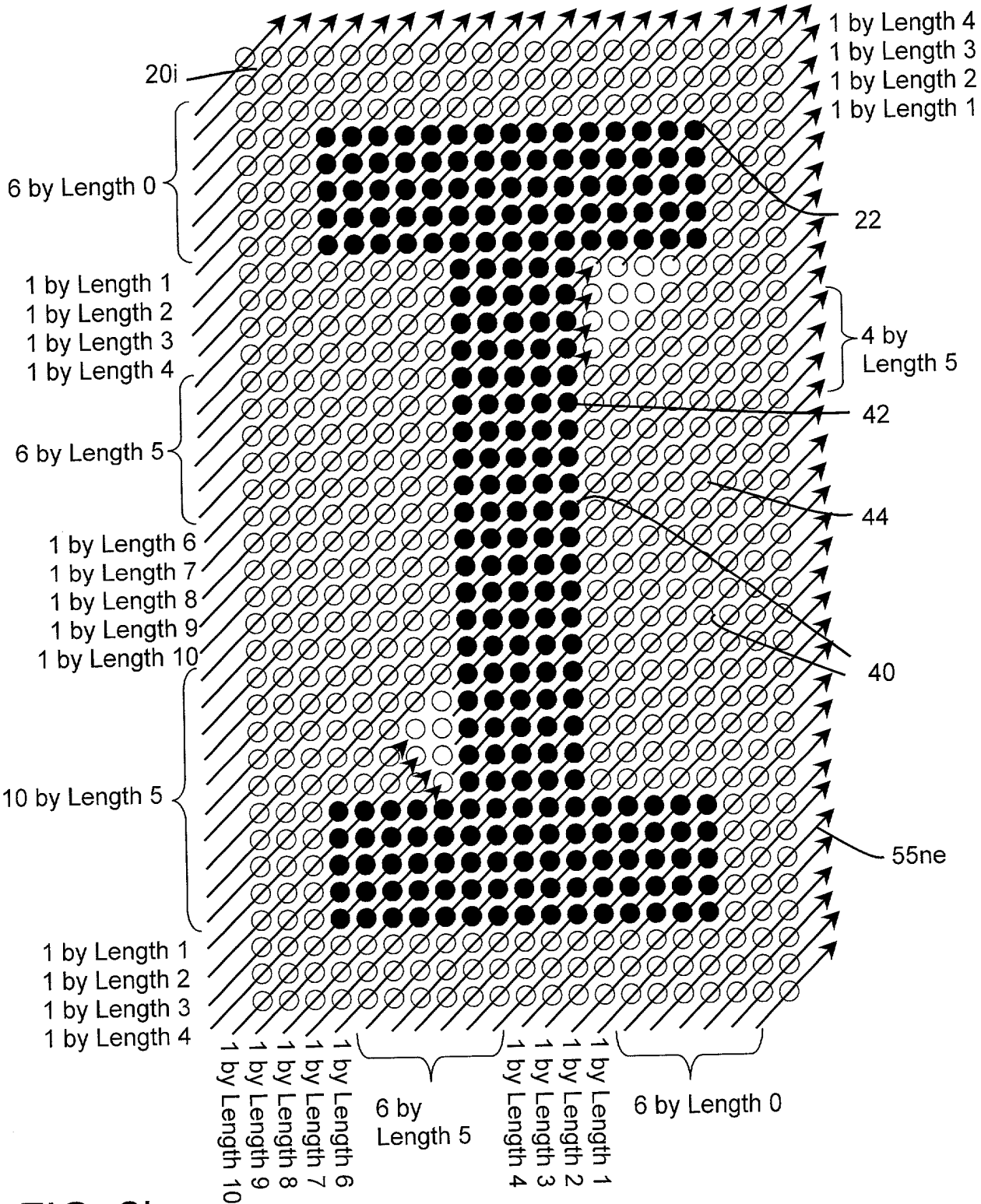



FIG. 2b

45° (northeast) algorithmic pixel-counting scan for average run-length determination

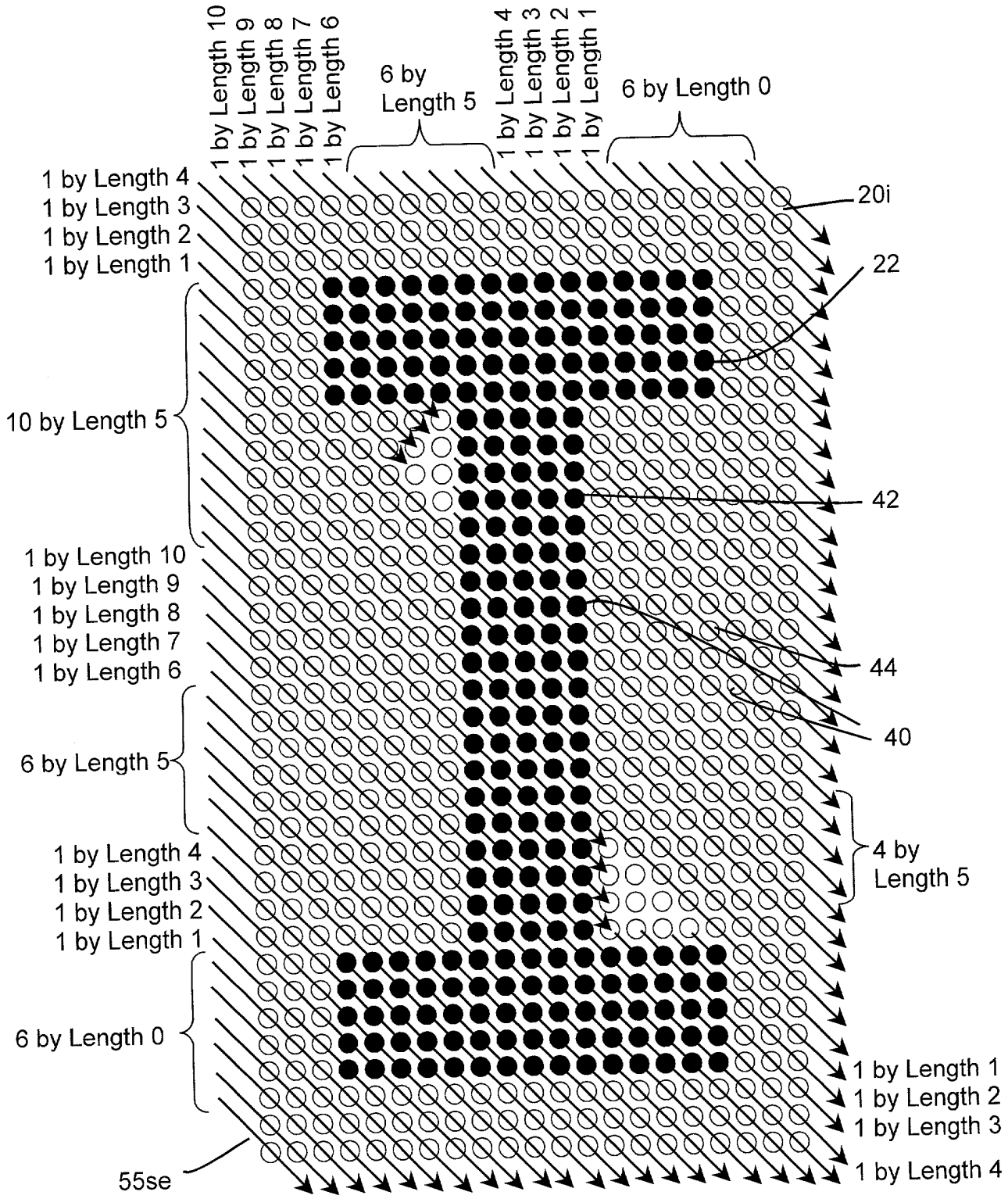
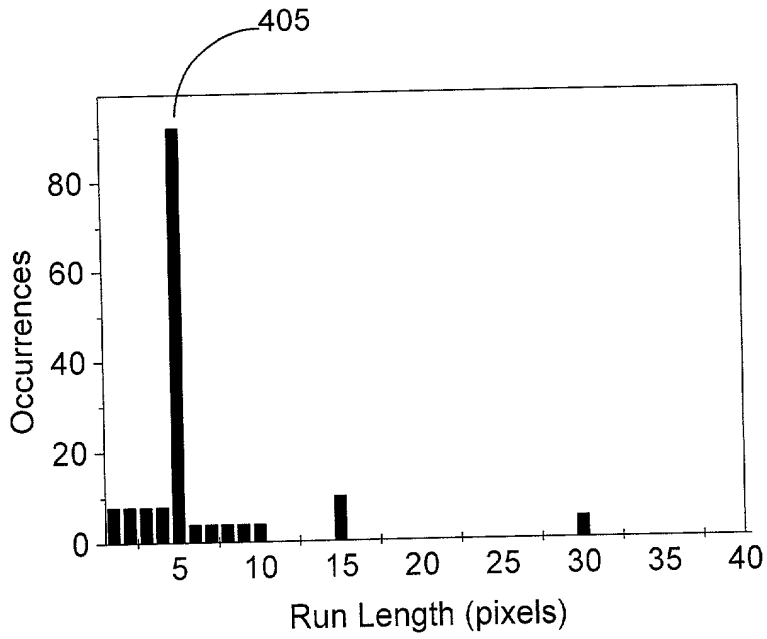


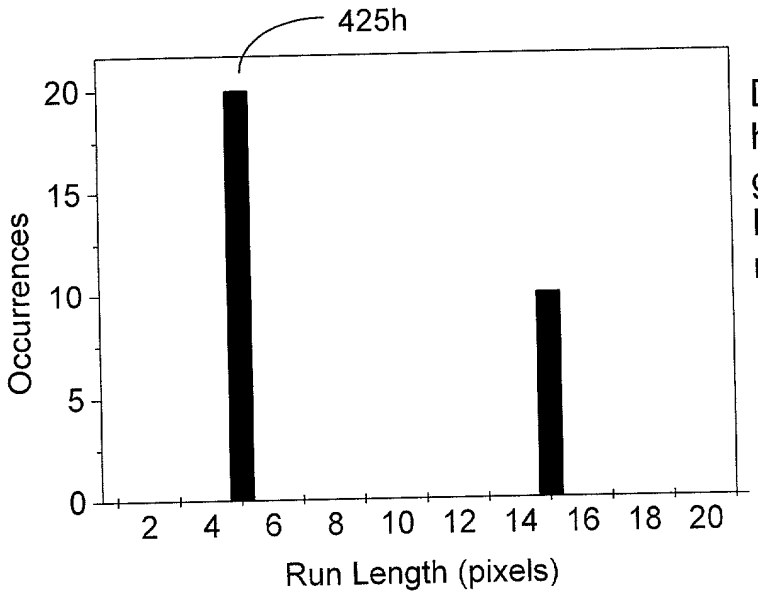

FIG. 2c

315° (southeast) algorithmic pixel-counting scan for average run-length determination



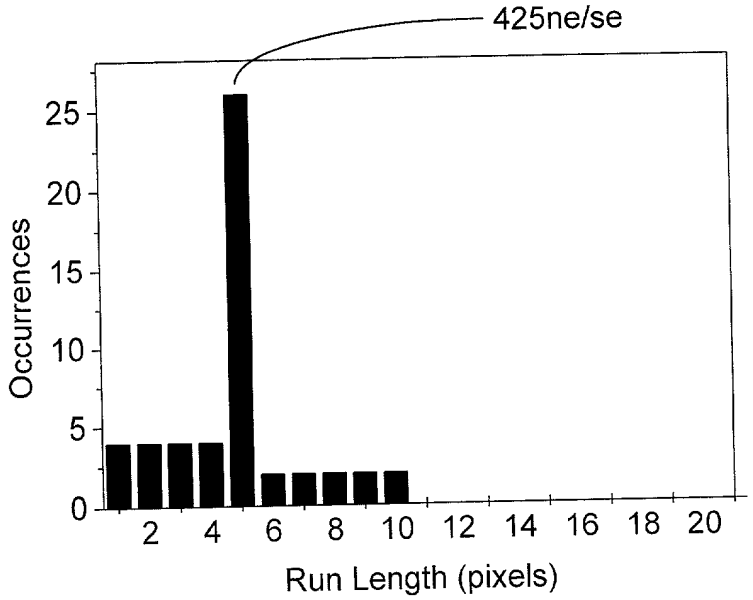

Cumulative Histogram, 400, for all four scan directions for I as represented in FIGS. 2 through 2c

FIG. 2d



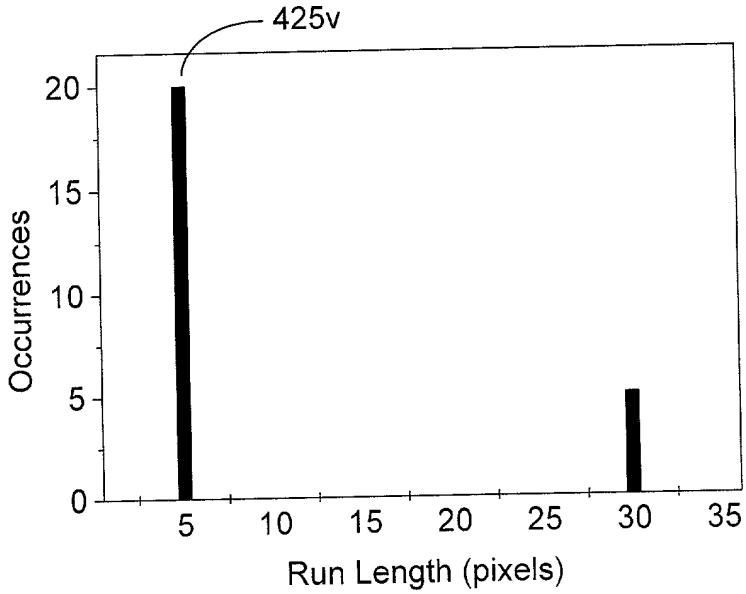

Direction-specific histogram, 420h, generated from Horizontal Scan of "I" as represented in FIG. 2a

FIG. 2e




Direction-specific histogram, 420ne/420se, generated from Northeast Scan of I as well as Southeast Scan of I as represented in FIGS. 2b and 2c

FIG. 2f




Direction-specific histogram, 420v, generated from Vertical Scan of I as represented in FIG 2a

FIG. 2g

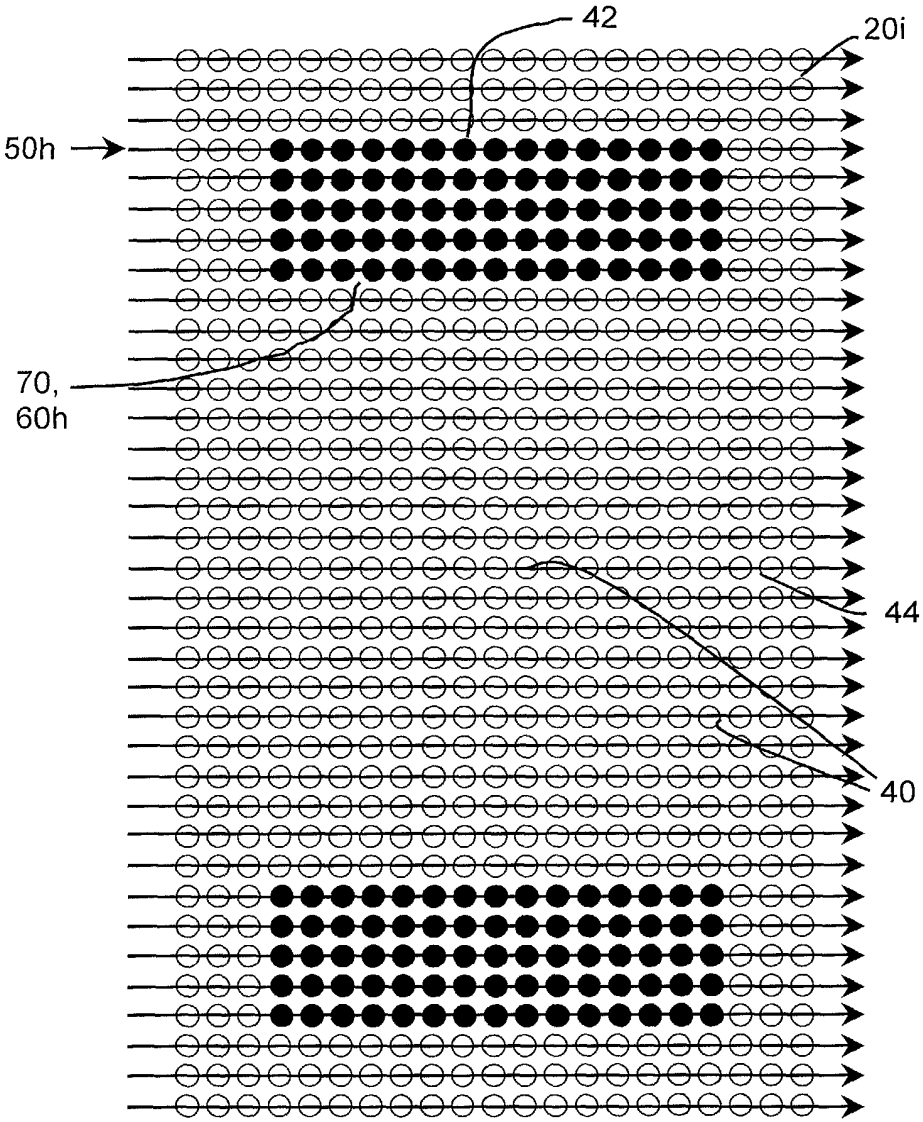



FIG. 2h Horizontal algorithmic extraction scan of the character "I"

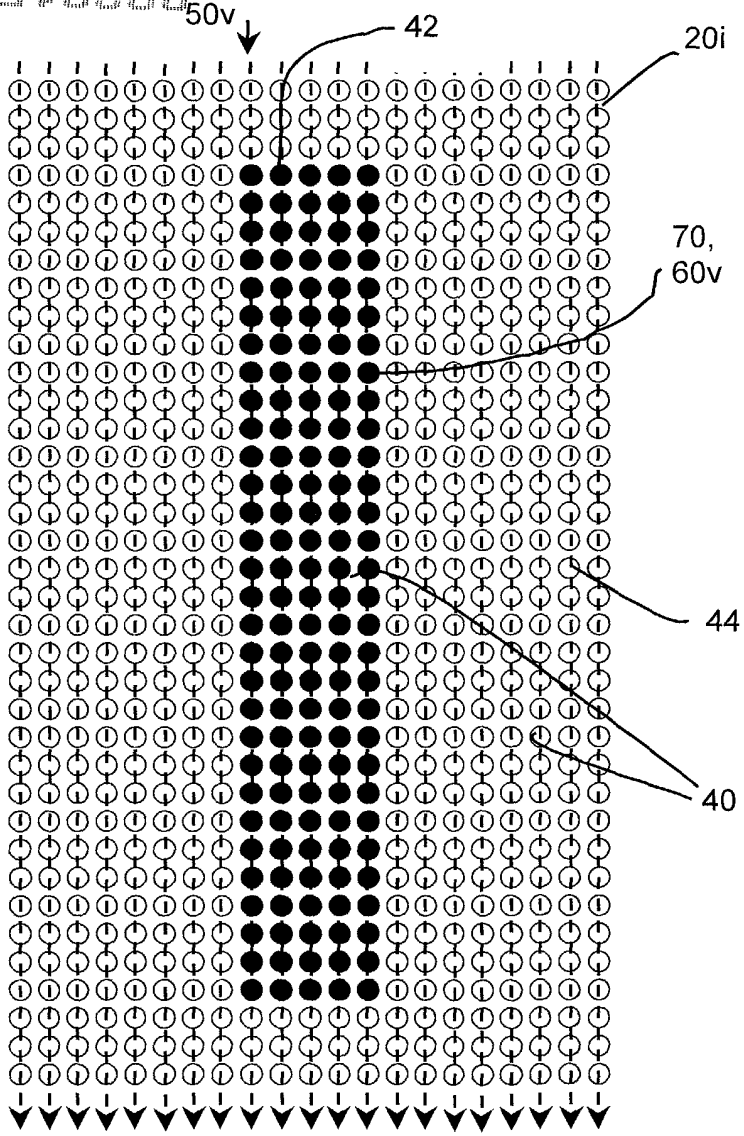



FIG. 2i Vertical algorithmic extraction scan of the character "I"

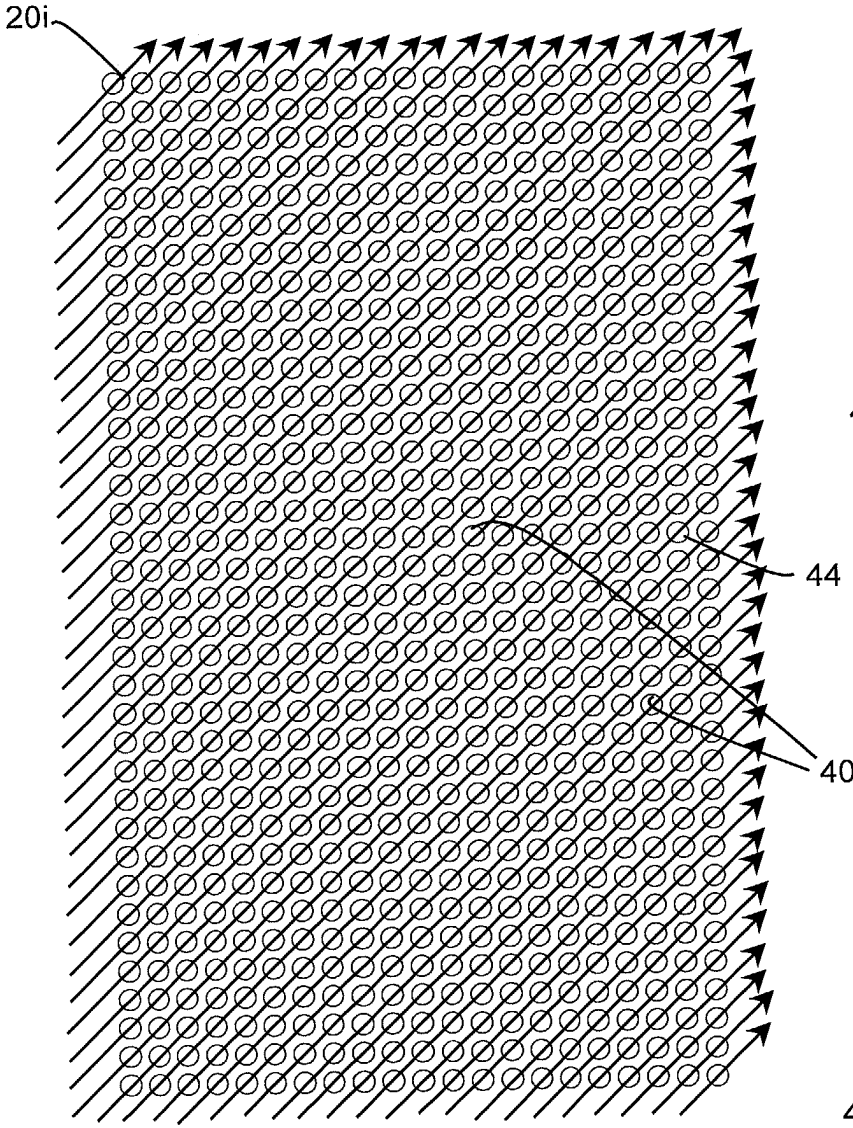



FIG. 2j

45° (northeast) algorithmic extraction scan of the character "I"

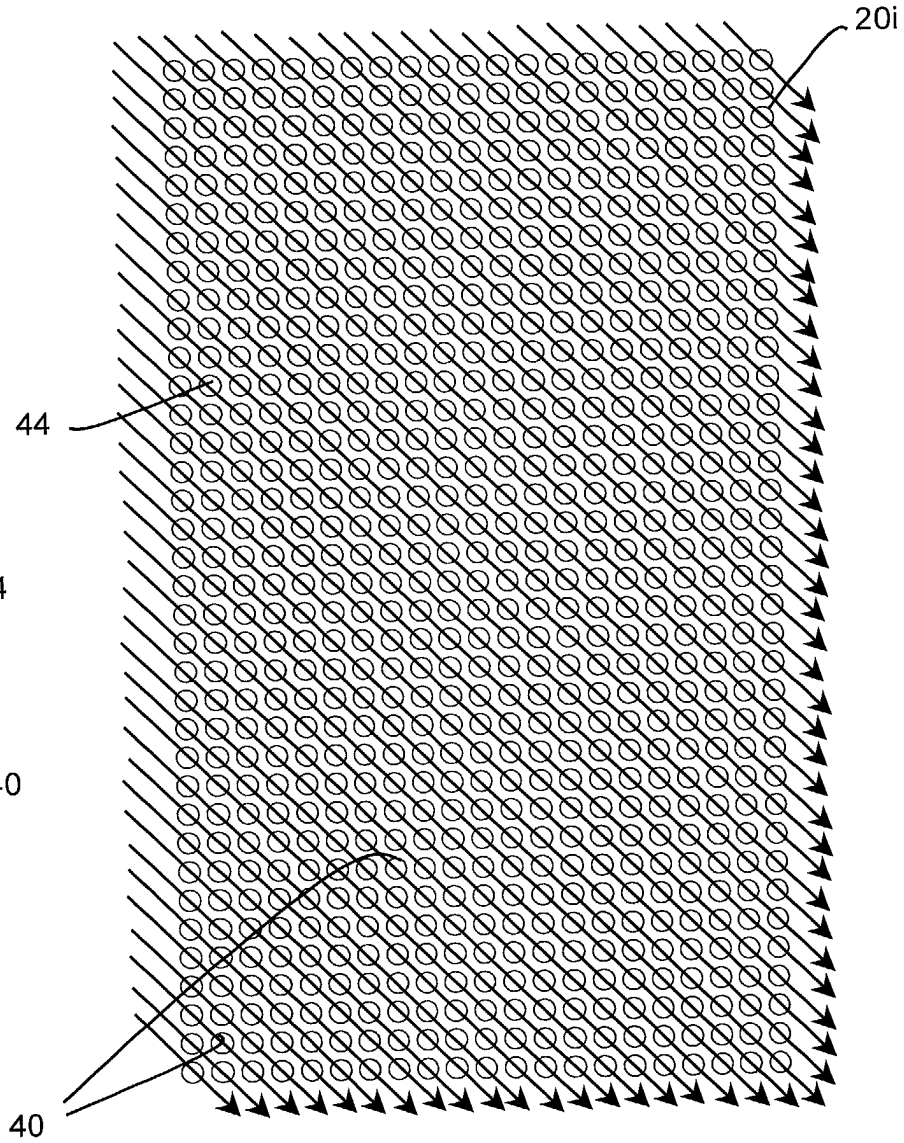



FIG. 2k

315° (southeast) algorithmic extraction scan of the character "I"

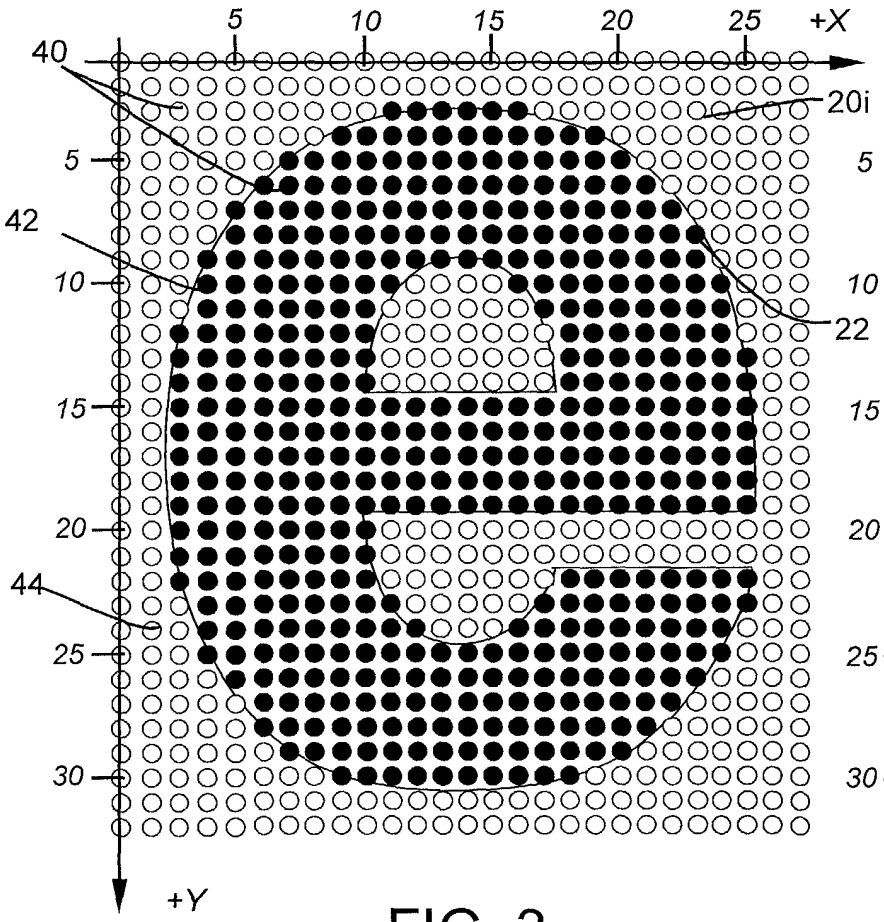



FIG. 3

There are 864 total character image pixels situated in an array 27 character pixels wide by 32 character pixels high. There are 457 character pixels and 407 background pixels.

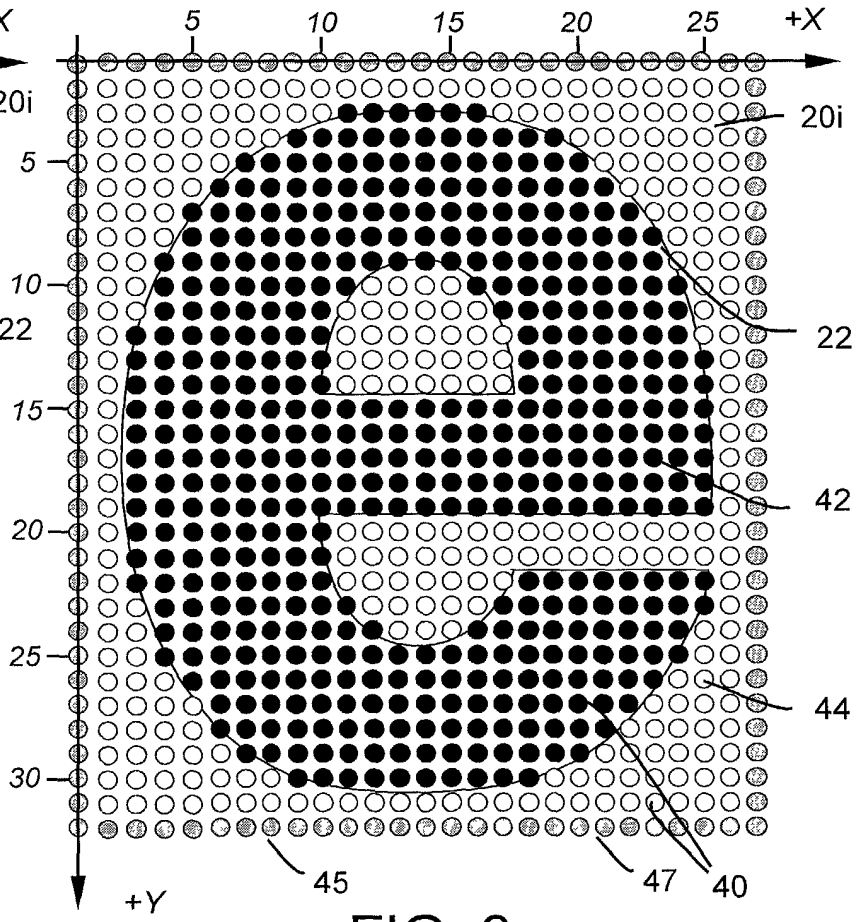



FIG. 3a

Of the 864 total character image pixels and 407 background pixels, 114 pixels are border or "edge" pixels defining the perimeter of the overall character image.

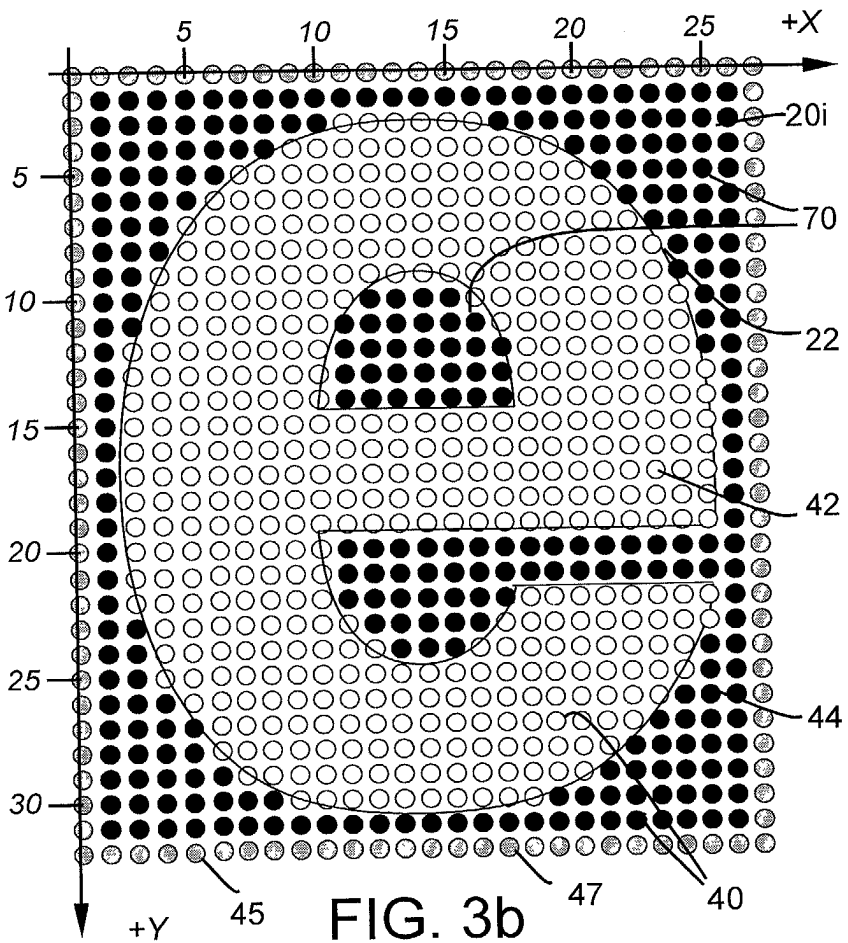



FIG. 3b

In a typical version, the character image is "complemented" for isolation of lakes and bays. In this case, two connected regions of black pixels remain after complementing.

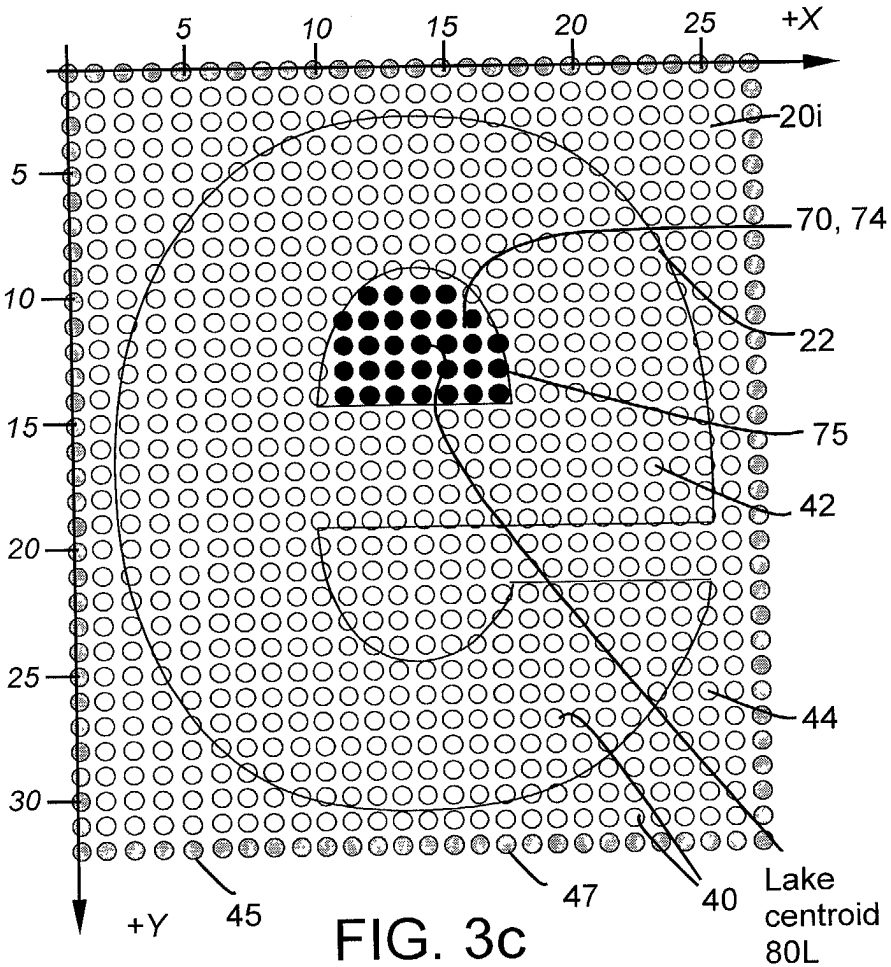



FIG. 3c

A lake is isolated by the exclusion of the connected region "touching an edge." The lake is comprised of 31 lake pixels. The centroid address is X=14, Y=12 (i.e., 14,12)

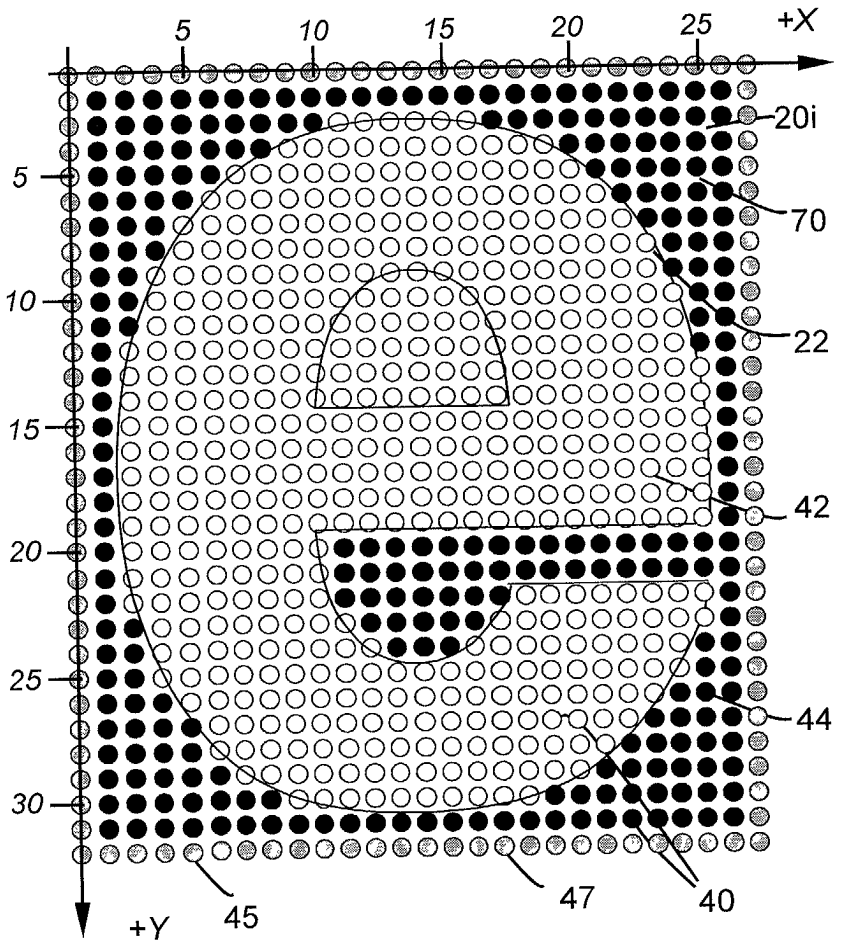



FIG. 3d

In order to isolate bays, lakes (in this case the one lake) are excluded by removing connected regions that "do not touch an edge" from the complemented character image. The single connected region remaining in this case is comprised of 369 background pixels, including the 114 border pixels.

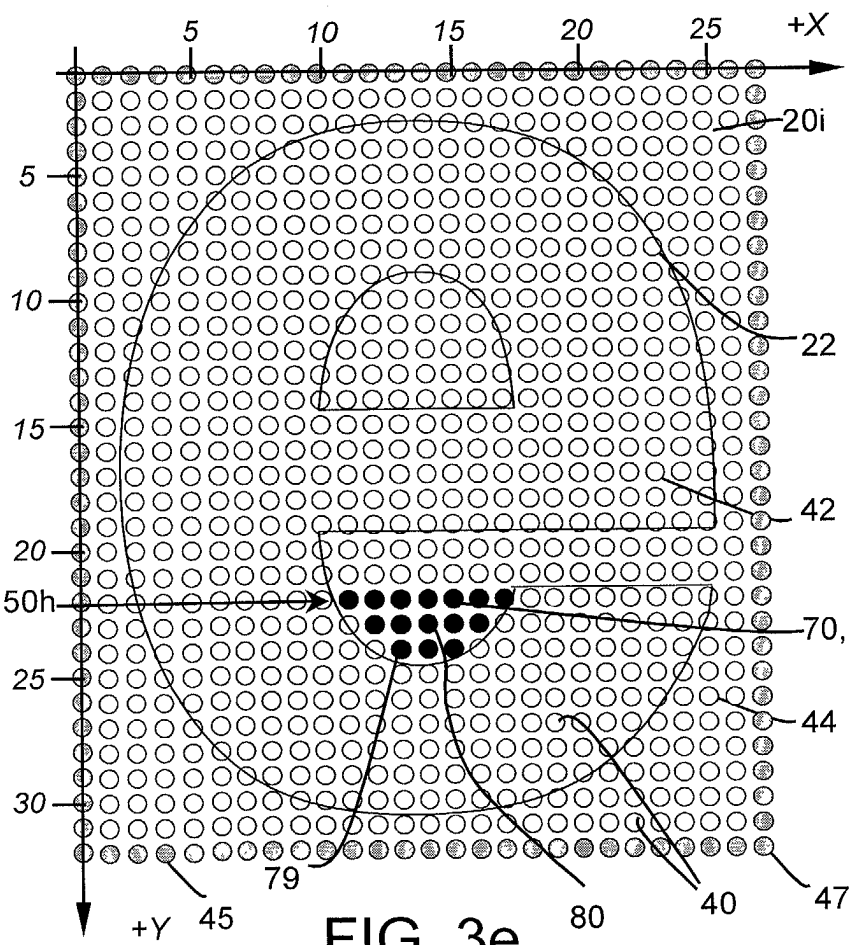



FIG. 3e

A horizontal bay-extraction scan that excludes horizontal runs touching the border yields a "horizontal bay" including 15 bay pixels with a centroid at (14,23).

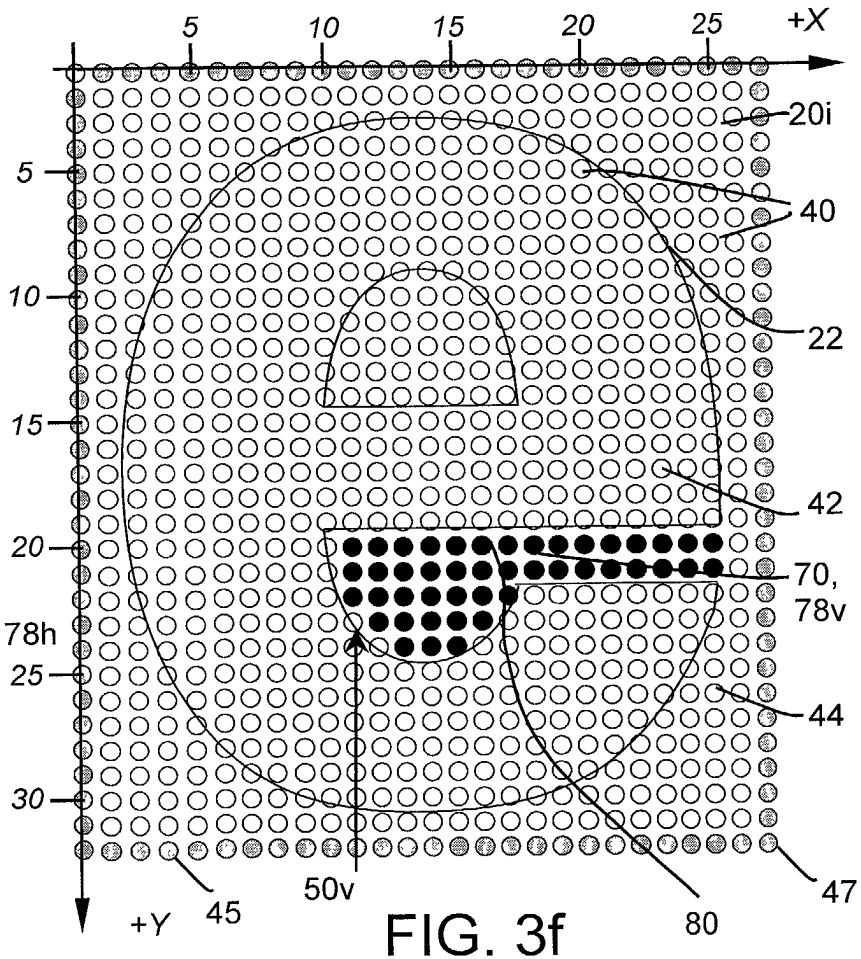



FIG. 3f

A vertical bay-extraction scan that excludes vertical runs touching the border yields a "vertical bay" including 47 pixels and having a centroid at (16,20).

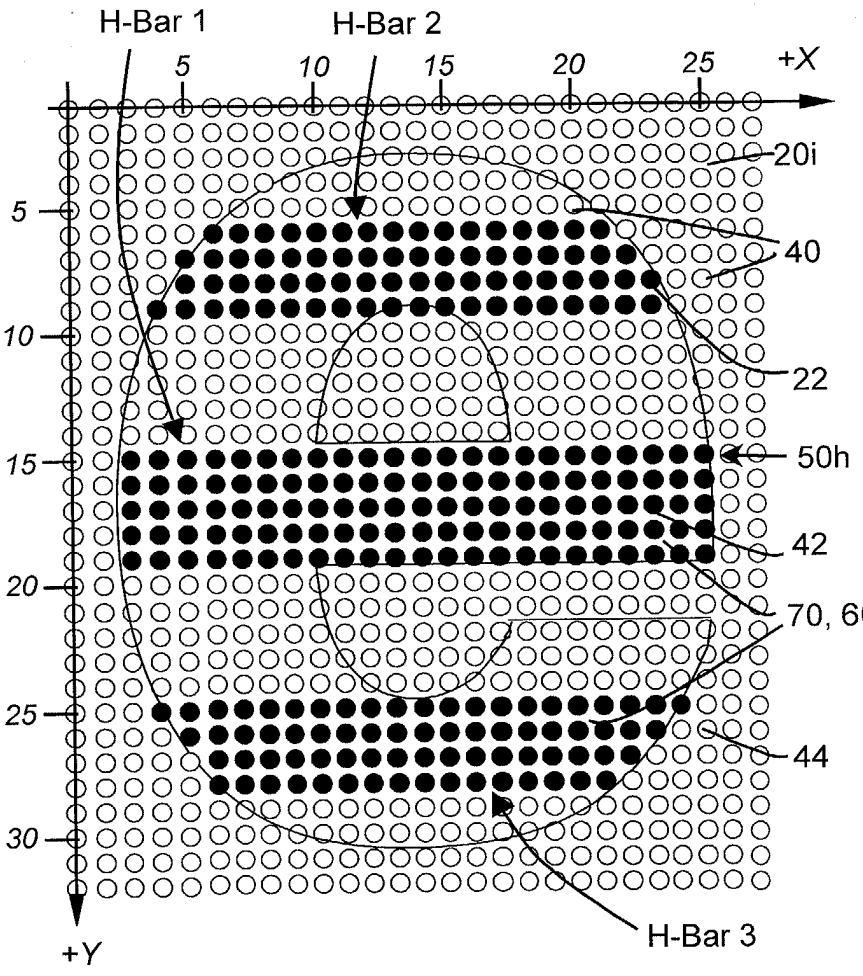



FIG. 3g

A horizontal bar-extraction scan yields 3 horizontal bars, a first with 5 runs and 115 pixels; a second with 4 runs and 73 pixels and a third with 4 runs and 73 pixels.

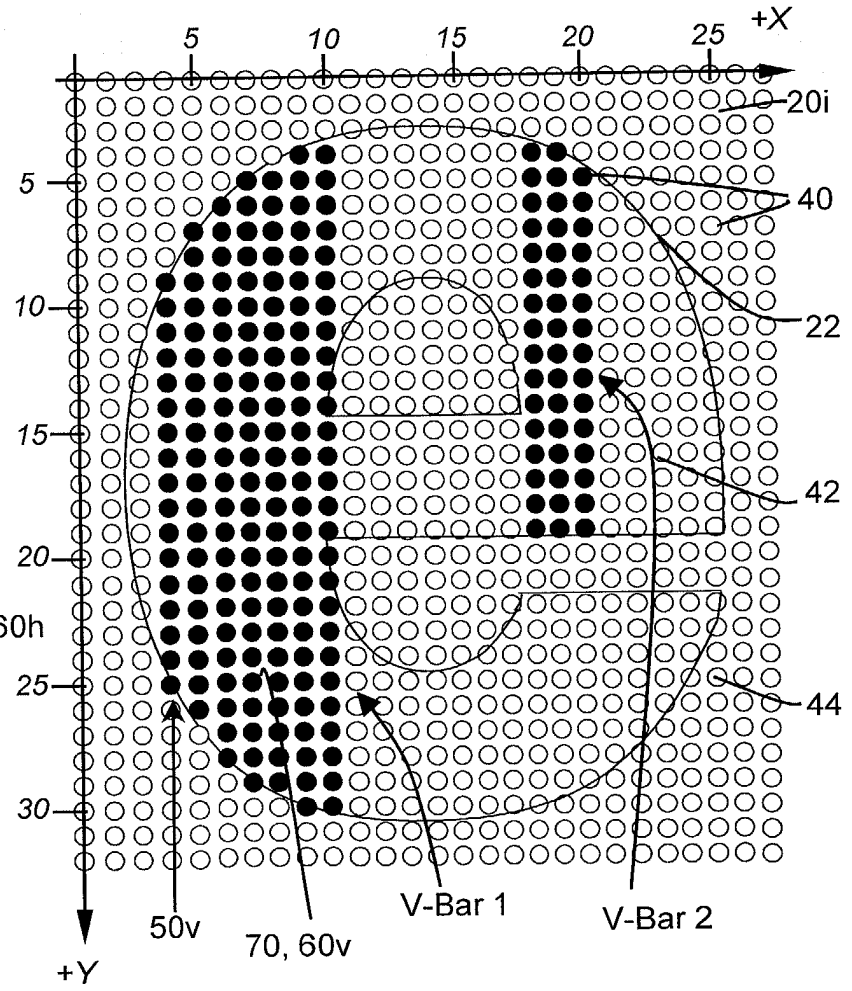



FIG. 3h

A vertical bar-extraction scan yields two vertical bars, a first with 7 runs and 164 pixels and a second with 3 runs and 47 pixels.

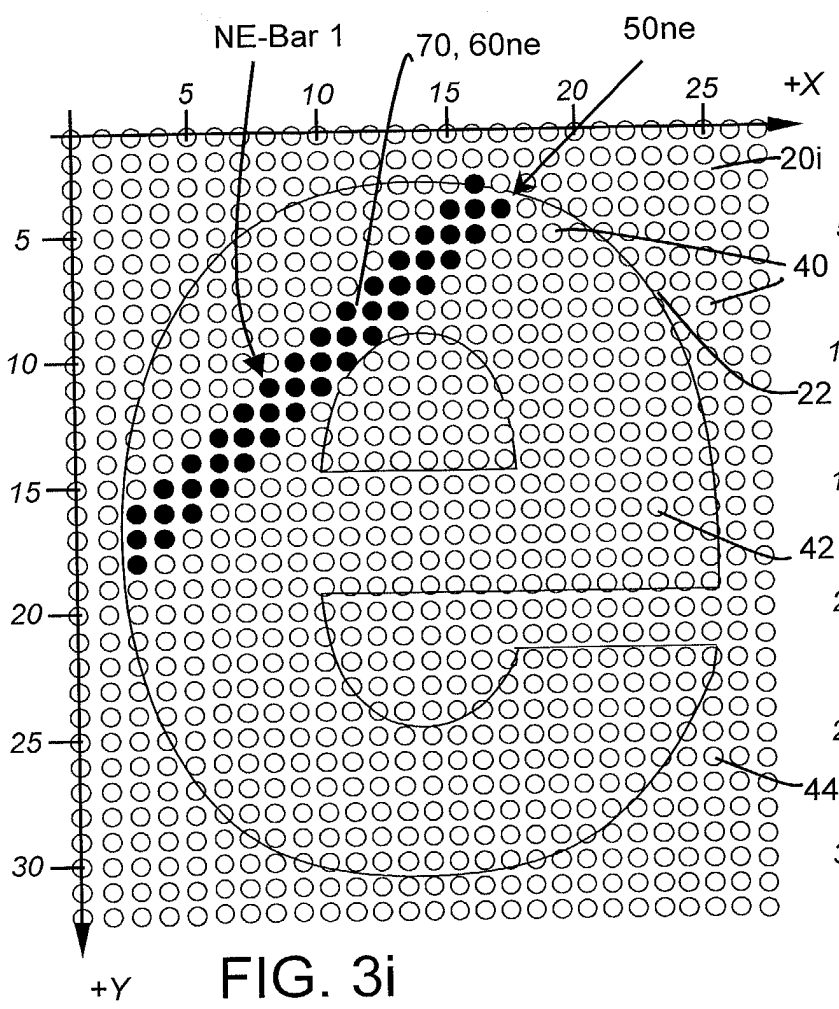



FIG. 3i

A northeast (45°) bar-extraction scan yields 1 northeast bar having 3 runs and 43 pixels

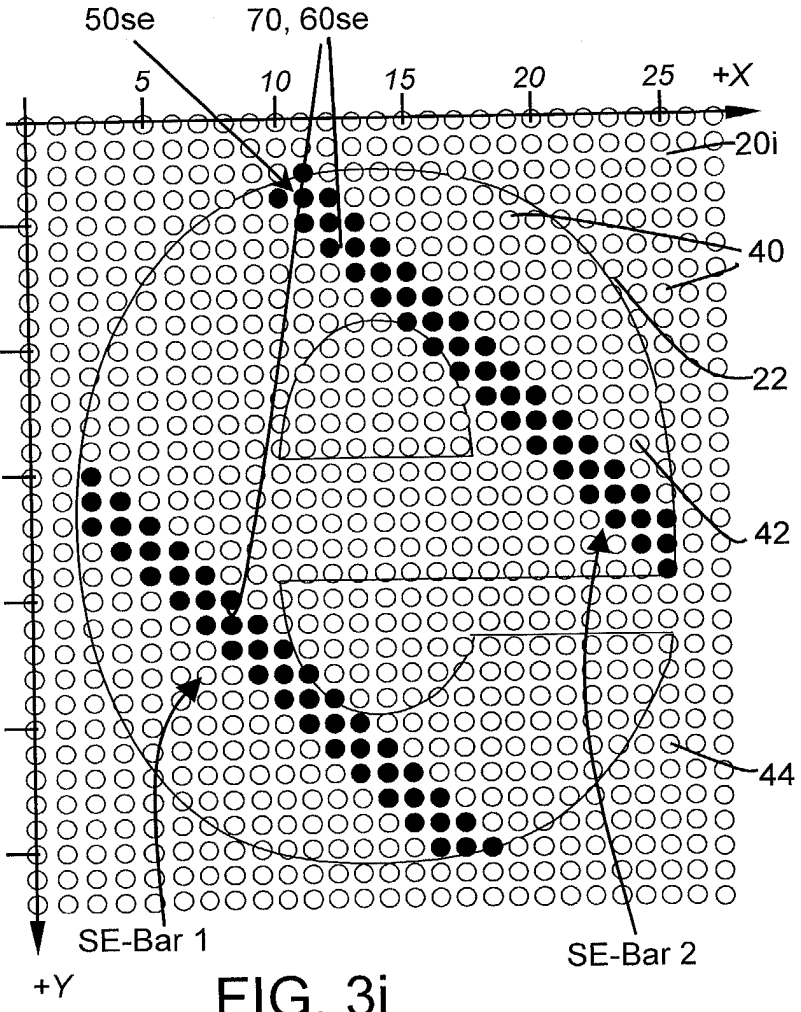



FIG. 3j

A southeast bar-extraction scan yields 2 southeast bars, a first with 3 runs and 43 pixels and a second with 3 runs and 46 pixels.

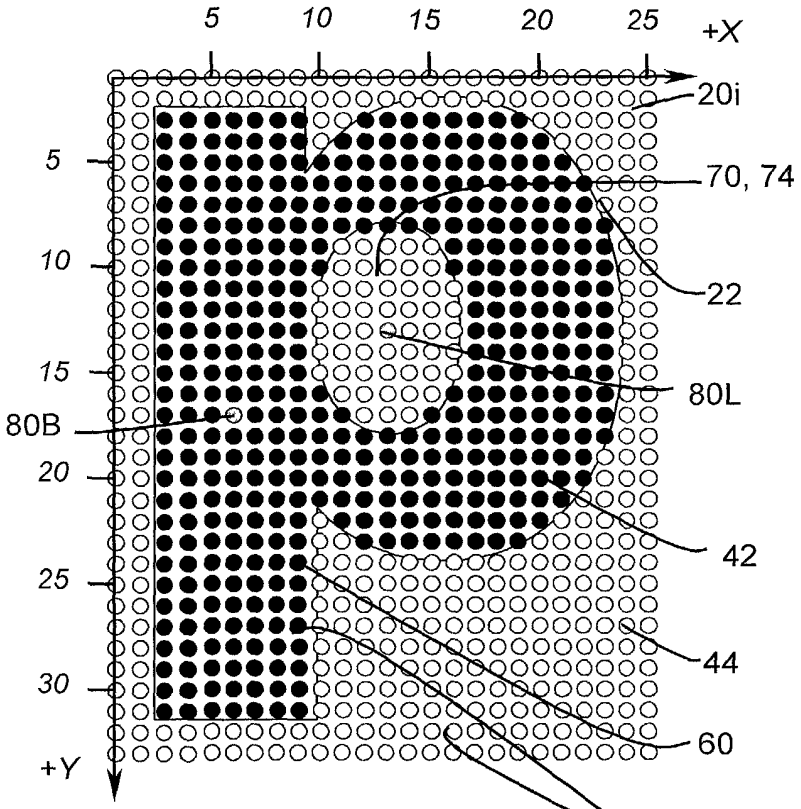



FIG. 4a

Bar centroid address is (6,17) and lake centroid address is (13,13)

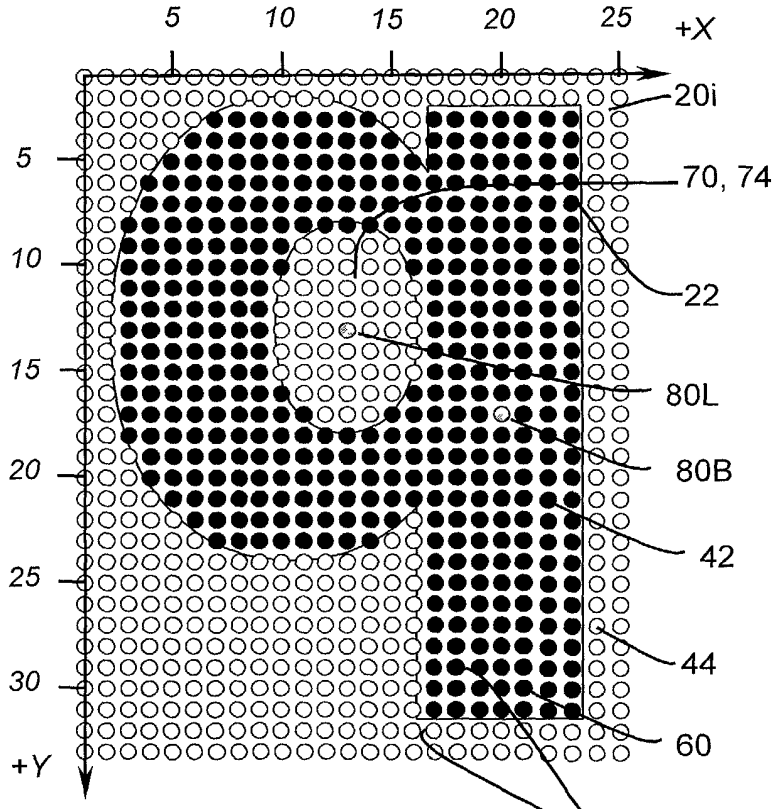



FIG. 4b

Bar centroid address is (20,17) and lake centroid address is (13,13)

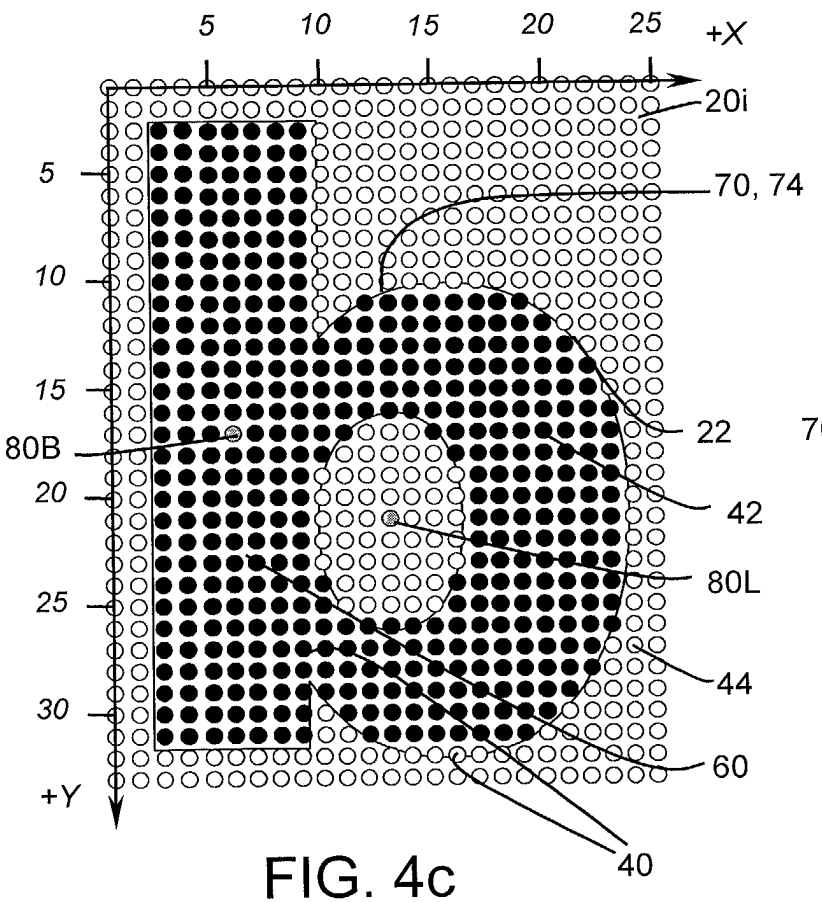



FIG. 4c

Bar centroid address is (6,17) and lake centroid address is (13, 21)

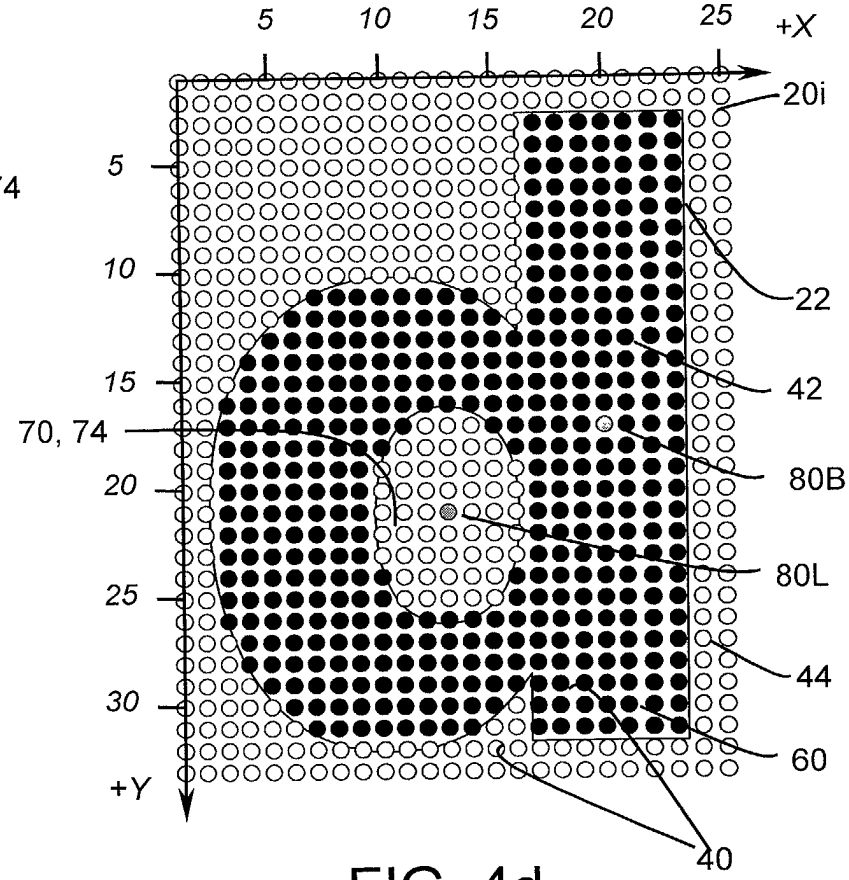



FIG. 4d

Bar centroid address is (20, 17) and lake centroid address is (13, 21)

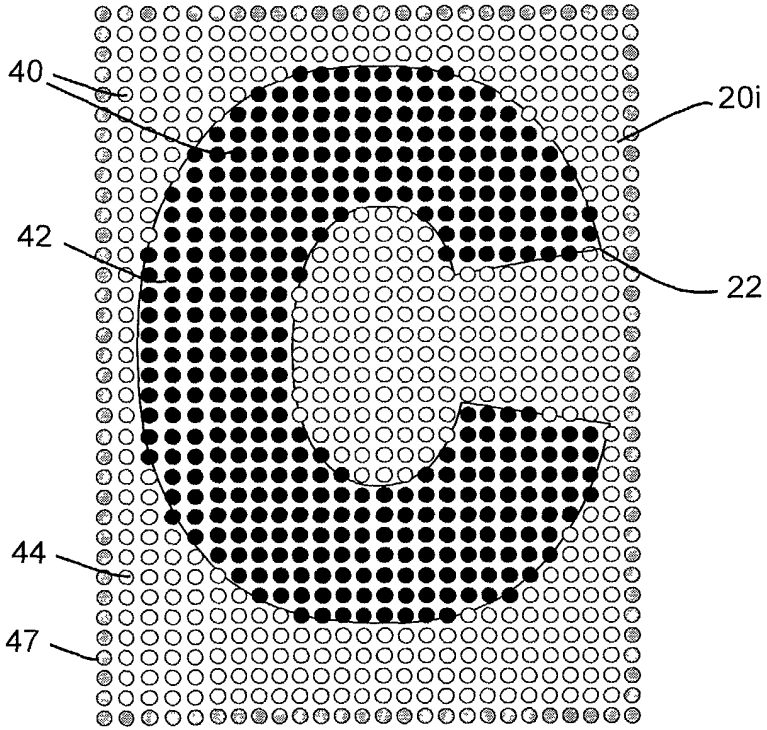



FIG. 5

A character image including the character image character "c" comprised of black character pixels and white background pixels.

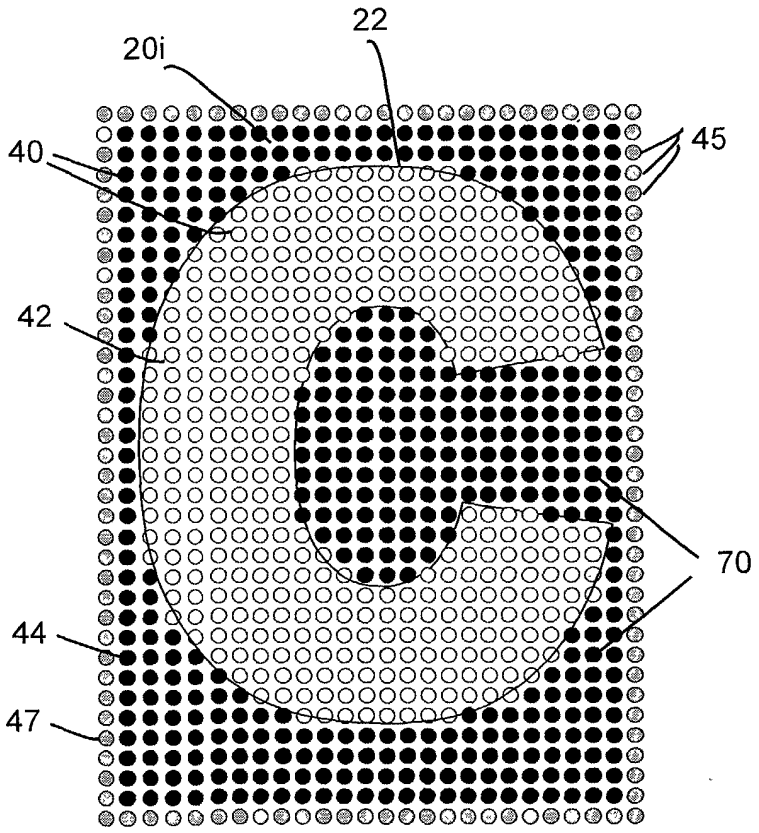



FIG. 5a

The complement of the character image in FIG. 5 including white character pixels and black background pixels.

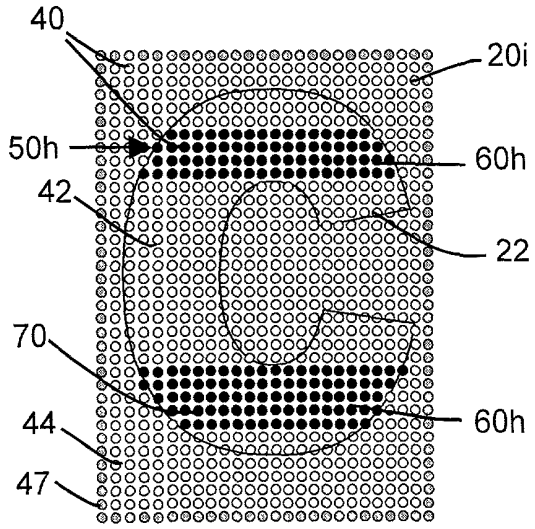



FIG. 5b

Horizontal Bar Extraction yields two horizontal bars **60h**

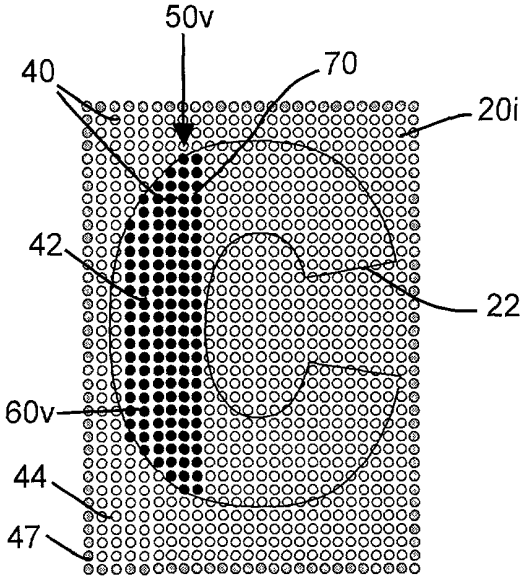



FIG. 5c

Vertical Bar Extraction yields two vertical bars **60v**

$\mathbf{SW_A}$ = 7
Extraction Threshold = $2\mathbf{SW_A}$ + 1

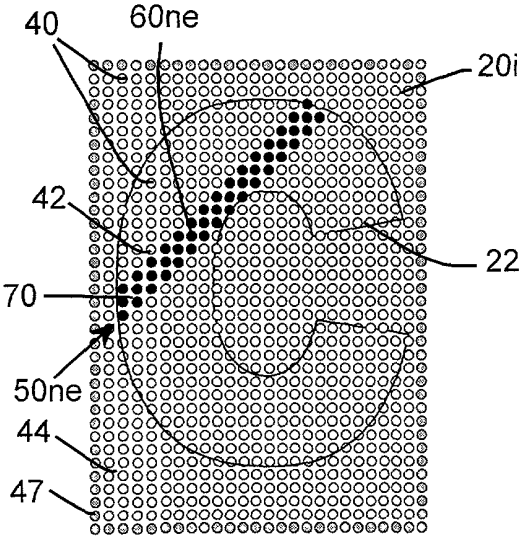



FIG. 5d

Northeast Bar Extraction yields one northeast bar **60ne**

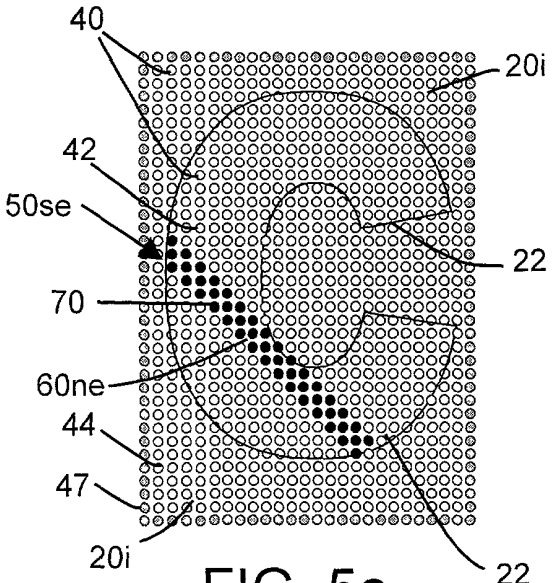



FIG. 5e

Southeast Bar Extraction yields one southeast bar **60se**

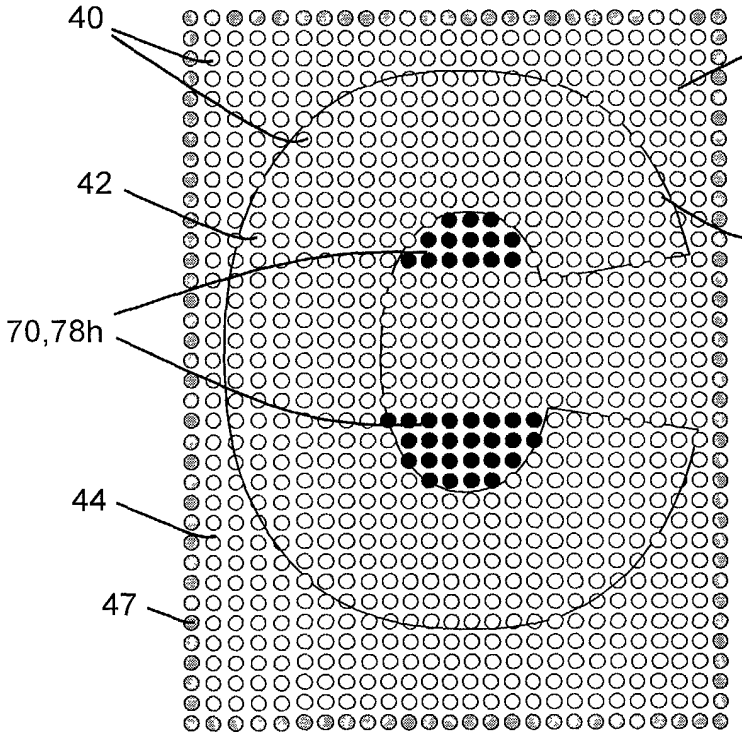



FIG. 5f

A horizontal bay-extraction scan that excludes horizontal runs touching the border yields two horizontal bays.

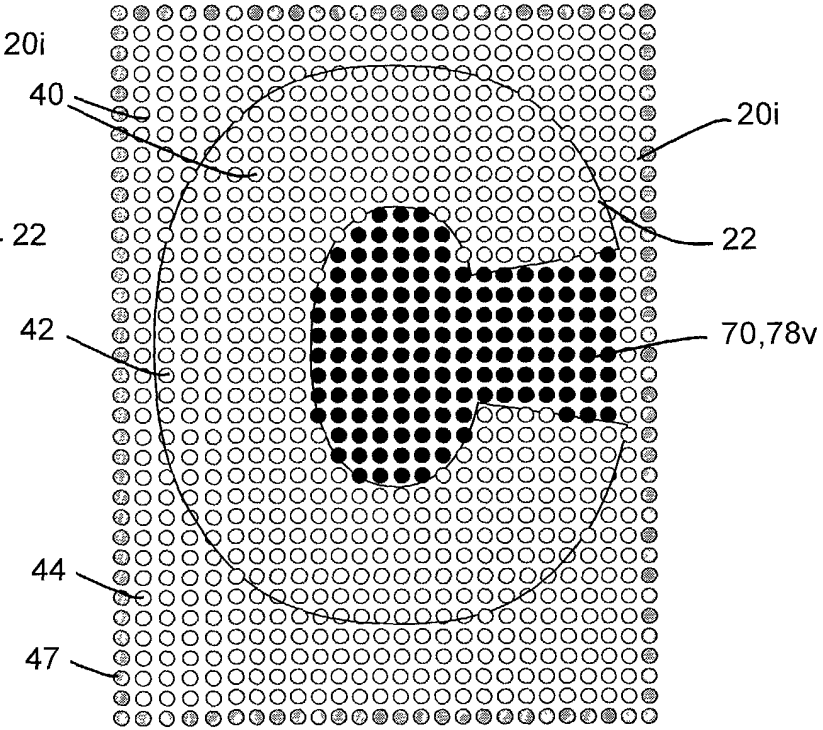



FIG. 5g

A vertical bay-extraction scan that excludes vertical runs touching the border yields a single vertical bay.

30

| End Vector | No. of v-bays | No. of h-bays | Begin Bays | No. of Lakes | Begin lakes | No. of ne-bars | No. of se-bars | No. of v-bars | No. of h-bars | Begin bars | Begin Vector |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | | 0 | | 1 | 1 | 1 | 2 | | |

# FIG. 5h

Illustrative assembled feature vector **30** assembled on the basis of the algorithmic extraction-scan results illustrated in FIGS. 5 through 5g.

| End Vector | . . . . | No. 315 deg. bars | . . . . | No. 45 deg. bars | . . . . | No. vert. bars | . . . | No. horiz. bars | Begin bars |
|---|---|---|---|---|---|---|---|---|---|
| | . . . . | 2 | . . . . | 1 | . . . . | 2 | . . . | 3 | |

| . . | No pixels v-bay 1 | No. of Vert. bays | . . . . . | Begin h-bay 1 horiz. runs | H-bay 1 centroid | No. bay pixels in h-bay 1 | No. of Horiz bays | Begin bays |
|---|---|---|---|---|---|---|---|---|
| . . | 50 | 1 | . . . . . | | 14,23 | 17 | 1 | |

| . . | V-Run 8 end | V-Run 8 begin | . . . . . | V-Run 1 end | V-Run 1 begin | No. Vert. Runs | Begin Lake 1 Vert. Runs | Run 6 end | Run 6 begin |
|---|---|---|---|---|---|---|---|---|---|
| . . | 17,14 | 17,12 | . . . . . | 10,14 | 10,14 | 8 | | 17,14 | 10,14 |

| . . . . . | H-Run1 end | H-Run 1 begin | No. Horiz. Runs | Begin Lake 1 Horiz. Runs | Lake 1 centroid | No. lake pixels in lake 1 | No. of lakes | Begin lakes |
|---|---|---|---|---|---|---|---|---|
| . . . . . | 14, 9 | 13, 9 | 6 | | 14,12 | 35 | 1 | |

| Image Orient. | No. of background pixels | No. of Char. pixels | No. of border pixels | Image Dimensions | No. of character image pixels | Begin new vector |
|---|---|---|---|---|---|---|
| 1 | 407 | 457 | 118 | 27 x 32 | 864 | Start vector |

To character recognition apparatus **170** →

An illustrative partial feature vector **30** includes data relating to bars **60**, lakes **74** and bays **78** extracted from the illustrative character image character "e" in FIGS. 3 through 3j.

**FIG. 6**

"C" is candidate output character indicated by comparison between assembled image feature vector of FIG. 5h and standard profiles corresponding to dictionary candidates

| | Bar quantity | | | | Lake quantity | Bay qty | |
|---|---|---|---|---|---|---|---|
| Character | h | v | se | ne | | h | v |
| A | 1 | 2 | 0 | 0 | 1 | 1 | 0 |
| B | 3 | 1 | 0 | 0 | 2 | 0 | 0 |
| C | 2 | 1 | 1 | 1 | 0 | 2 | 1 |
| D | 2 | 2 | 1 | 1 | 1 | 0 | 0 |
| E | 3 | 1 | 0 | 0 | 0 | 0 | 2 |
| F | 2 | 1 | 0 | 0 | 0 | 0 | 1 |
| G | 3 | 2 | 0 | 0 | 0 | 2 | 1 |
| H | 1 | 2 | 0 | 0 | 0 | 2 | 0 |
| I | 2 | 1 | 0 | 0 | 0 | 0 | 2 |
| J | 0 | 1 | 1 | 1 | 0 | 1 | 0 |
| K | 0 | 1 | 1 | 1 | 0 | 2 | 1 |
| L | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| M | 0 | 4 | 0 | 0 | 0 | 3 | 0 |
| N | 0 | 2 | 1 | 0 | 0 | 2 | 0 |
| O | 2 | 2 | 2 | 2 | 1 | 0 | 0 |
| P | 2 | 1 | 0 | 0 | 1 | 0 | 0 |
| Q | 2 | 2 | 1 | 0 | 1 | 0 | 0 |
| R | 2 | 1 | 1 | 0 | 1 | 1 | 1 |
| S | 2 | 0 | 1 | 0 | 0 | 2 | 2 |
| T | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| U | 1 | 2 | 1 | 1 | 0 | 1 | 0 |
| V | 0 | 2 | 0 | 0 | 0 | 1 | 0 |
| W | 0 | 4 | 0 | 0 | 0 | 3 | 0 |
| X | 0 | 0 | 1 | 1 | 0 | 2 | 2 |
| Y | 0 | 1 | 1 | 1 | 0 | 1 | 0 |
| Z | 2 | 1 | 0 | 0 | 0 | 0 | 2 |

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Additional vector data required to distinguish

Additional vector data required to distinguish

185

188

**FIG. 7**

Partial standardized profile list in illustrative dictionary

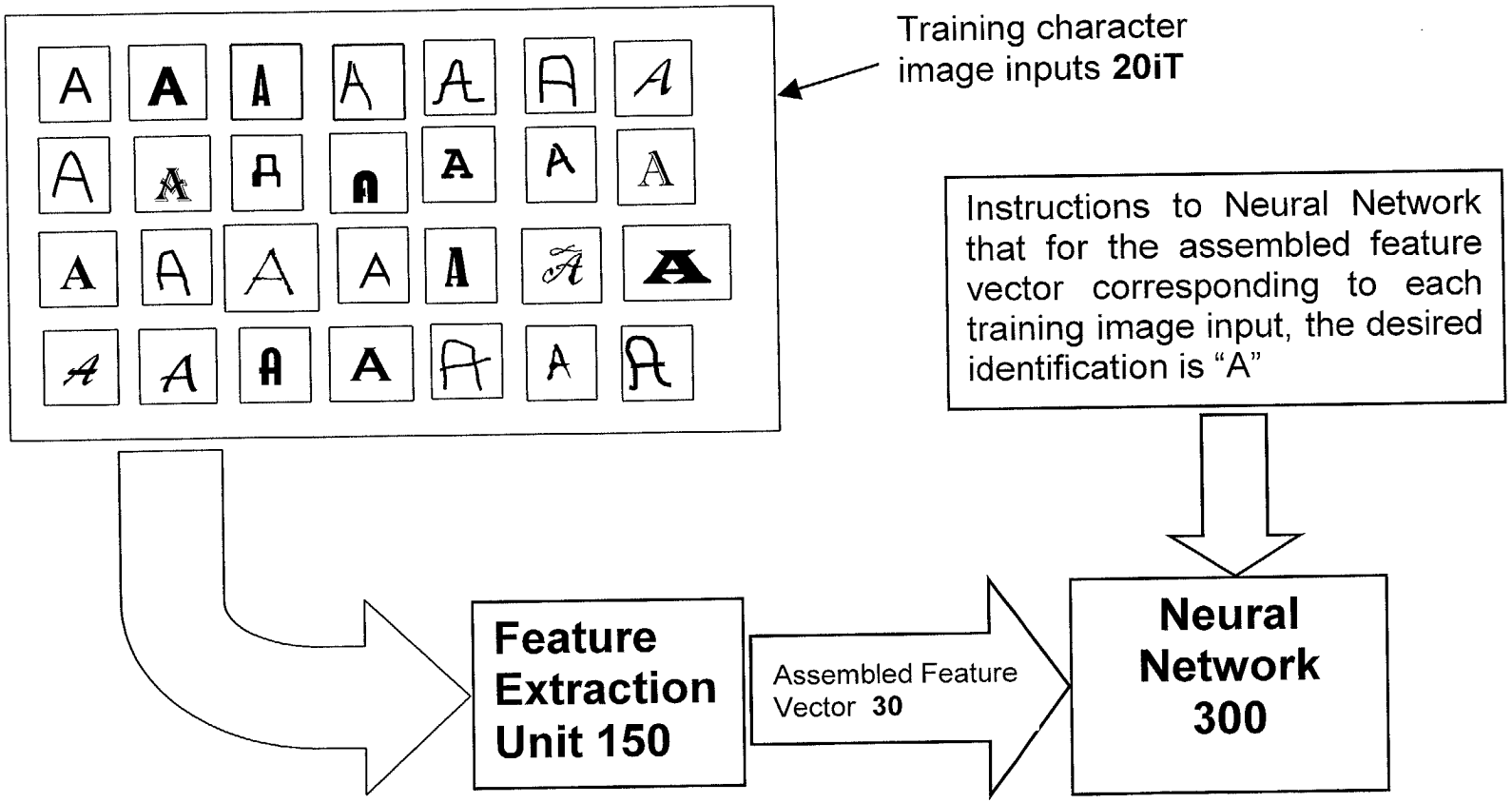


**FIG. 8** A neural network being trained to recognize numerous illustrative variations of the character "A"

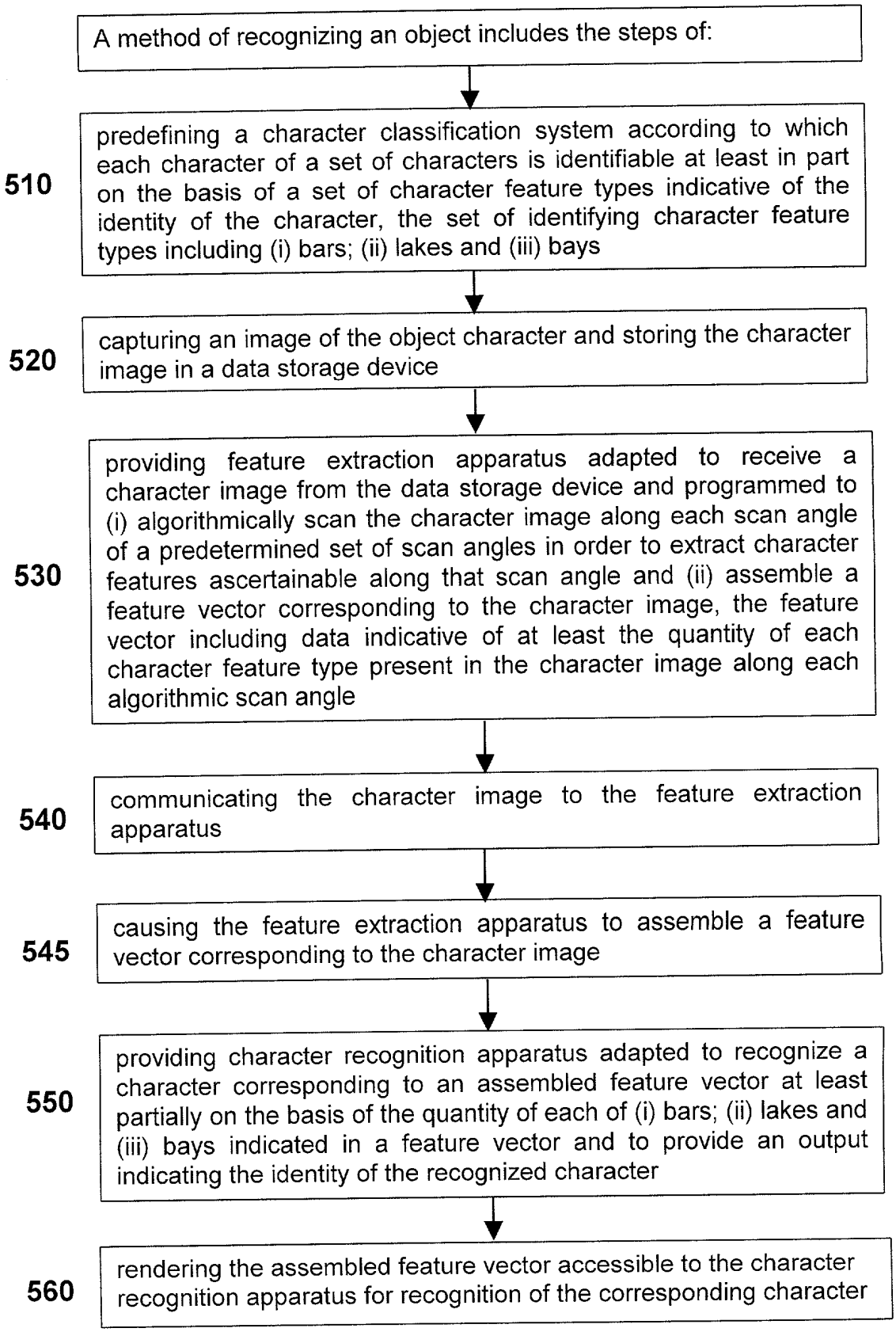
A method of recognizing an object includes the steps of:
510
predefining a character classification system according to which each character of a set of characters is identifiable at least in part on the basis of a set of character feature types indicative of the identity of the character, the set of identifying character feature types including (i) bars; (ii) lakes and (iii) bays
520
capturing an image of the object character and storing the character image in a data storage device
530
providing feature extraction apparatus adapted to receive a character image from the data storage device and programmed to (i) algorithmically scan the character image along each scan angle of a predetermined set of scan angles in order to extract character features ascertainable along that scan angle and (ii) assemble a feature vector corresponding to the character image, the feature vector including data indicative of at least the quantity of each character feature type present in the character image along each algorithmic scan angle
540
communicating the character image to the feature extraction apparatus
545
causing the feature extraction apparatus to assemble a feature vector corresponding to the character image
550
providing character recognition apparatus adapted to recognize a character corresponding to an assembled feature vector at least partially on the basis of the quantity of each of (i) bars; (ii) lakes and (iii) bays indicated in a feature vector and to provide an output indicating the identity of the recognized character
560
rendering the assembled feature vector accessible to the character recognition apparatus for recognition of the corresponding character

FIG. 9